

A NOVEL FABRICATION METHOD OF EMBEDDED MICRO CHANNELS EMPLOYING SIMPLE UV DOSAGE CONTROL AND ANTIREFLECTION COATING

*F. G. Tseng, Y. J. Chuang, and W. K. Lin

Engineering and System Science Dept.

National Tsing Hua University, Taiwan

*Fax: 886-3-5720724, email: fangang@ess.nthu.edu.tw

ABSTRACT

This paper proposes a novel method to fabricate multi-layers of embedded micro fluidic structures by simply employing time-controlled UV exposure on thick SU-8 resist and anti-reflection coating on the bottom surface to eliminate the reflection light induced exposure. Testing result shows the top wall thickness of embedded channels can be well controlled in a resolution of $2\text{ }\mu\text{m}$ for the UV dose $120\text{--}190\text{ mJ/cm}^2$. Stacked channels have also been successfully fabricated and showed no interference on the bottom structures when exposing the top structures. This simple and inexpensive method can be applied to fabricate multi-layers of complex fluidic systems, as shown in Fig. 1, for the applications of μTAS , inkjet printhead, capillary electrophoresis, and micro PCR, etc.

INTRODUCTION

There have been many micromachining approaches to fabricate buried micro channels, such as wafer bonding after bulk micro machining [1], sacrificial etching by surface micromachining [2], and through mold plating [3], etc. Besides, LIGA or micro stereolithography can also realize micro channel structures. However, those processes either are complex, expansive, require high temperature/electrical field, or need special

equipments for fabrication, not as easy as the use of photopolymers such as SU-8 resist [4]. There are at least four major methods which have been reported by using SU-8 resist to fabricate buried channel structures, including: (1) SU-8 plus filling materials to form channel spaces [5], (2) using

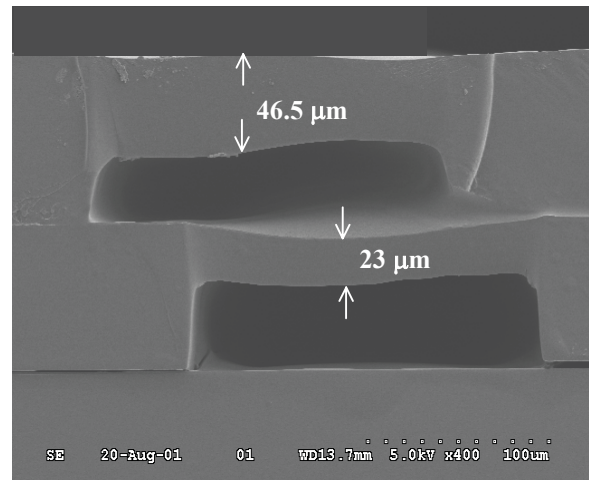


Fig. 1 Fabricated stacked Su-8 buried channels by UV dosage control.

metal mask to protect from second exposure for forming channel spaces [5], (3) employing laminated SU-8 and Riston film to form channel spaces [4], (4) utilizing proton beam to partially expose SU-8 to form buried channels [6], as shown in fig. 2 (a)-(d), respectively. The first method must apply two materials and at least three lithography steps to finish one layer of buried channel, and the filling materials may induce steps affecting successive processes, not mention the

troublesome material compatibility problem between two different materials. The second process employed metal masks for UV light

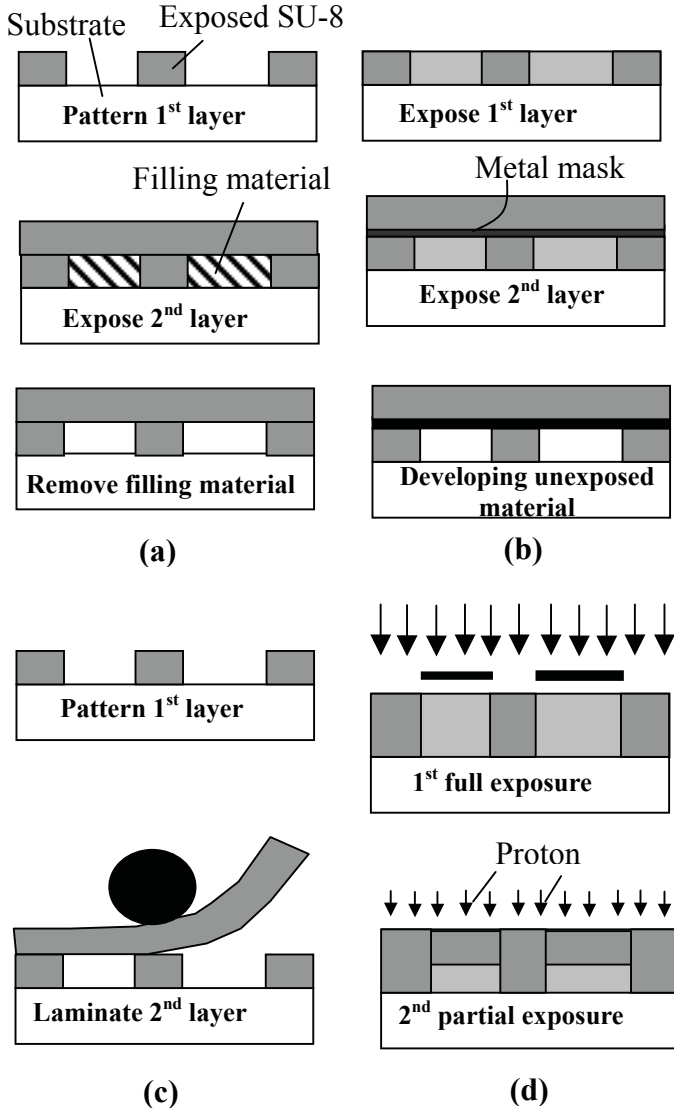


Fig. 2 Four buried channel methods by SU-8 resist [4-6]

protection, but the crack of metal thin film during elevated temperature by evaporation process or the later baking process may potentially fail the stacking process; besides, the metal removal process could pose structure damage. Laminating process in the third method may pose the adhesion uniformity problem between two materials. In the fourth mean, proton may be an elegant approach for dosage control on resist exposure, but not a popular

source for common use. In summary, the traditional methods for buried SU-8 channels either use more than two materials and tedious processes, or costly facilities like proton beam, not simple enough for the fabrication of stacked channels. On the other hand, it will be a simpler process if UV light can be employed for dosage control to fabricate buried channels.

CONCEPTS AND FABRICATION

The reason for the aforementioned tedious methods to fabricate buried channels by SU-8 photoresist without employing UV dosage control is the high transparency of the resist. When using partial exposure of UV light to get desire exposure

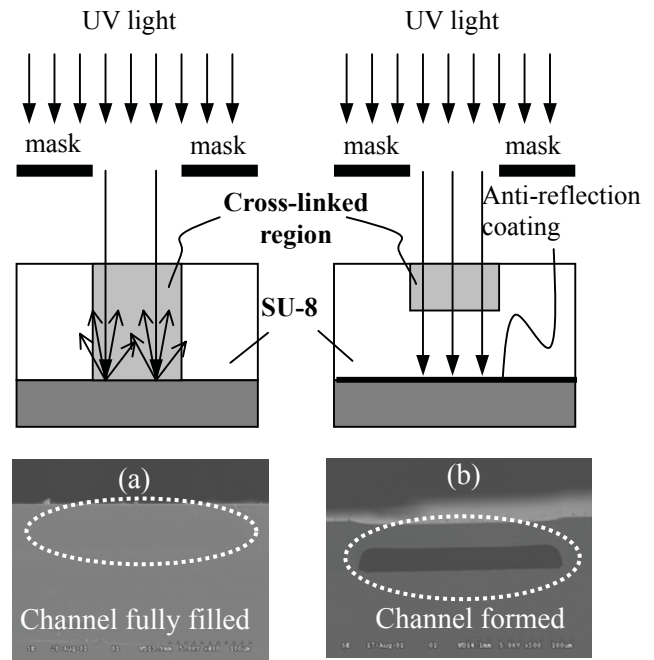


Fig. 3 UV exposure under (a) normal situation (b) with anti-reflection coating

thickness, the bottom of the channel is usually get exposed by the reflected UV light from the photoresist/wafer interface, as shown in Fig. 3 (a). As a result, channel height is very hard to control by partial exposure. The channels encounter issues such as collapse from under-dosage or fill-up

from the reflection light with normal dosage. The process window for channel formation is very narrow and hard to hit and repeat.

This paper proposes a novel approach, as shown in Fig. 3 (b), employing antireflection layer on the resist-wafer interface to absorb reflected UV light, thus thoroughly eliminate the reflection issue. Thanks to the absorption of the extra UV light by the antireflection layer, the exposure window are widely open for various process parameters and allows accurate control of exposure depth. Fig. 4 shows the detail process.

Fabrication starts from the spin-on of FujiFilm CK-6020L resist, the antireflection coating and commercially used for filter, for UV light absorption, and then desire thickness of SU-8 resist (Fig. 4a). After the first exposure to define the channel wall (Fig. 4b), a partial second exposure is then applied to define the channel top region (Fig. 4c). Post exposure bake is required before the fabrication of the successive stacking layers to ensure good structure boundary definition. The second antireflection layer is then applied for the partial exposure of the next layer (Fig. 4d). Multi-layers of channel structures can be obtained simply by repeating the processes (Fig. 4e). After the fabrication of all layers, channel structures can be released by one developing process (Fig. 4f). However, care need to be taken to remove the antireflection layer by solvent during the developing process to open up the developing path for the lower channels.

EXPERIMENT RESULTS

This simple process has been routinely employed to fabricate channels with accurate top wall thickness and channel structure. Fig. 5 shows six different channel top-wall thickness of 14, 23.2, 27.2, 31,

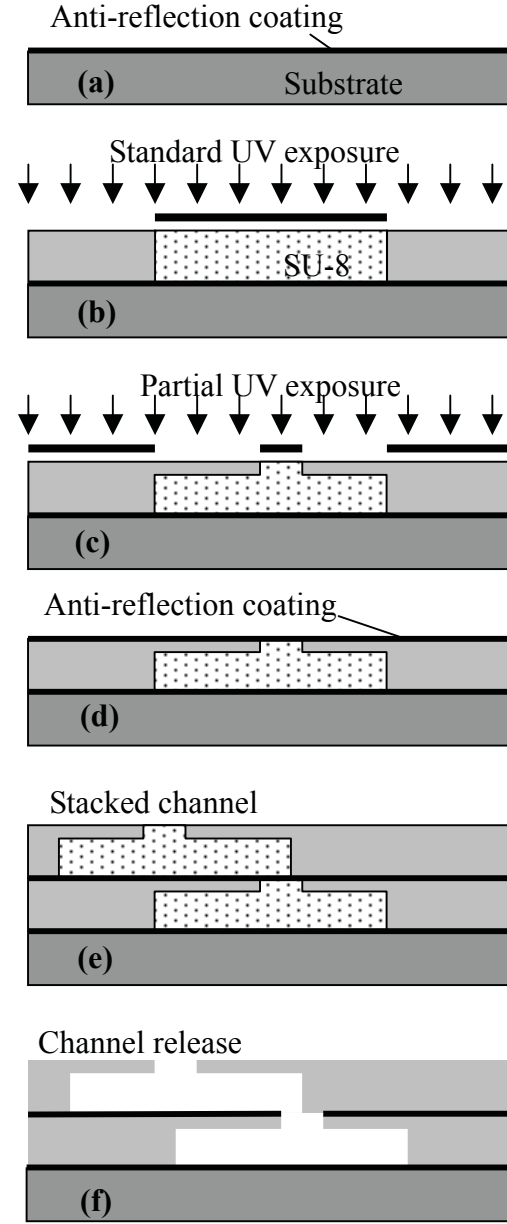


Fig.4 Fabrication process of stacked channels

45.2, 61.1 μm , which were under UV exposure (365 nm) for 122.5, 161.7, 176.4, 191.1, 196, 200.9 mJ/cm^2 , respectively. The relationship between thickness and exposure dosage is shown in Fig. 6, bi-linearly related for 120-200 mJ/cm^2 . Above 31 μm the resist seems to be more sensitive to the UV dose thus the thickness control is not as accurate as those below the threshold value. To verify if this simple method can be employed for the fabrication of multiple buried channel layers, a double stacked

channels were designed and processed, and successfully demonstrated the possibility of

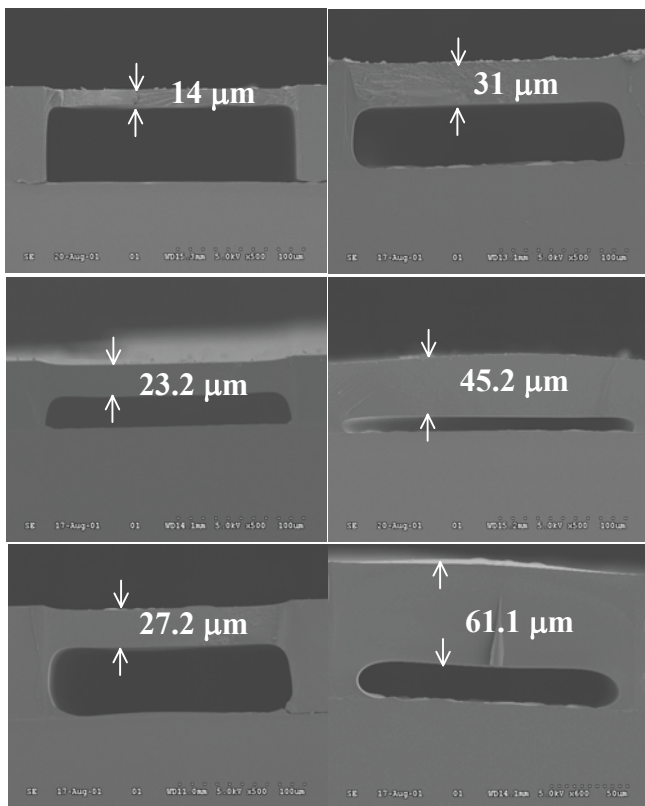


Fig. 5 Thickness control by different UV dosage

fabrication of stacking channels. The result has already been shown in Fig. 1. Note the distortions of the channels are due to the wafer breaking process to reveal the inner structure, not from the lithography. Channels are well defined without interference, which suggest the possibility of the fabrication of complex fluidic systems with multi-layers.

CONCLUSIONS

A novel fabrication method of embedded micro channels employing simple UV dosage control and antireflection coating has been proposed and successfully demonstrated. Different from other SU-8 processes for buried channel fabrication, this method elegantly employs simple UV dosage to control exposure depth while using antireflection coating to absorb surplus UV dose to prevent

channel bottom exposure. This process shows good control of channel top wall thickness, and potentially applicable to complex micro fluidic systems and Bio-MEMS.

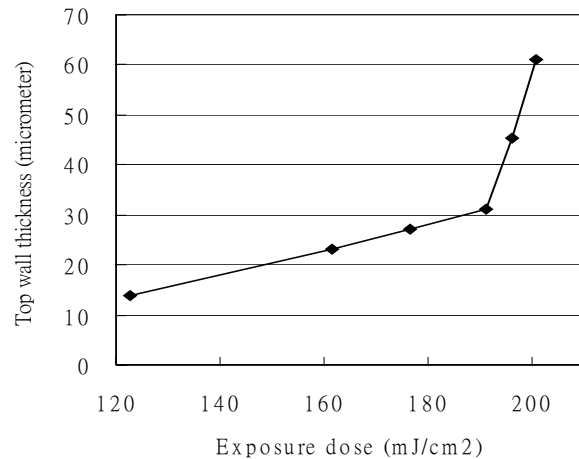


Fig. 6 Wall thickness vs. UV exposure dose

ACKNOWLEDGEMENTS

This work is supported by National Science Council through the contracts NSC 89-2218-E-044 and NSC 89-2323-B-007-005.

REFERENCES

- [1] M. Alavi, S. Buttgenbach, A. Schumacher, Sens. Actuators A 32, pp. 299-302, 1992.
- [2] J. Chen, K. D. Wise, IEEE Transducers'95, June 25-29, pp. 321-324, 1995.
- [3] J.D. Lee, J. B. Yoon, J. K. Kim, H. J. Chung, C. S. Lee, H. D. Lee, H. J. Lee, C. K. Kim, and C. H. Han, J. of MEMS, vol. 8, No. 3, pp. 229-236, Sep., 1999.
- [4] M. O. Heuschkel, L. Guerin, B. Buisson, D. Bertrand, P. Renaud, Sens. Actuators B 48, pp. 356-361, 1998.
- [5] L. J. Guerin, M. Bossel, M. Demierre, S. Calmes, Ph. Renaud, IEEE Transducers'97, Chicago, USA, pp. 1419-1422, 1997.
- [6] F. E. H. Tay, J.A. V. Kan, F. Watt, and W. O. Choong, J. Micromech. Microeng. 11, pp. 27-32, 200